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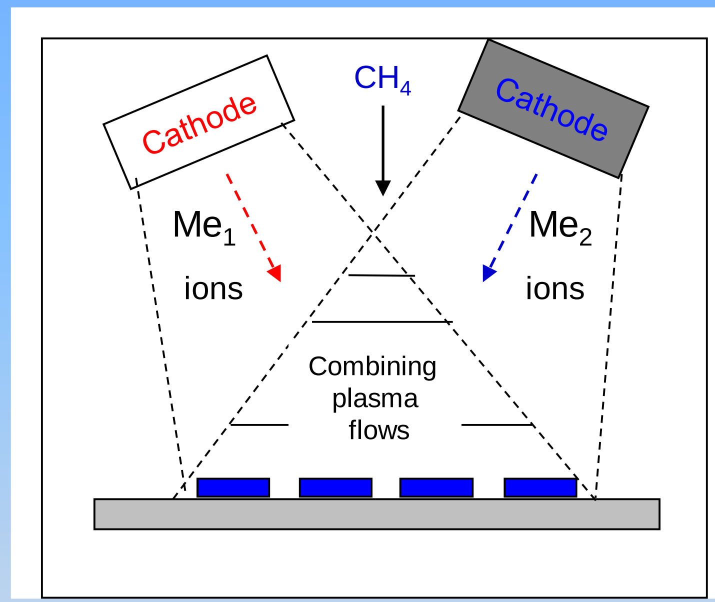
Synthesis of Layered Coatings from Solid Solutions of Niobium, Zirconium and Titanium Carbides on Hard Alloy Tool Using Vacuum Arc Deposition

Kuleshov Andrej, **Uglov Vladimir, Rusalsky Dmitry**, **Barkouskay Maryna**

Belarusian State University, Res. lab. «Physics of Ion-Plasma Modification of Solids»,4 Nezavisimosti ave., 220030 Minsk, Belarus

Solid Solutions of Niobium, Zirconium and Titanium Carbides on Hard Alloy Tool Using Vacuum Arc Deposition from Solid Solutions of Niobium, Zirconium and Titanium Carbides

Deposition equipment (VU-2MBS)



Cathodic Arc Vapor Deposition (CAVD) is characterized by the creation of a metal vapor by cathode spot of the arc and that can be reacted with different gases to form a coating.

Scheme of the* layered *carbide coatings formation

- high amount of ionization of plasma flows (up to 100%);
- high energy of bombarding ions (hundred eV);
- using of a one or few cathodes and different gases.

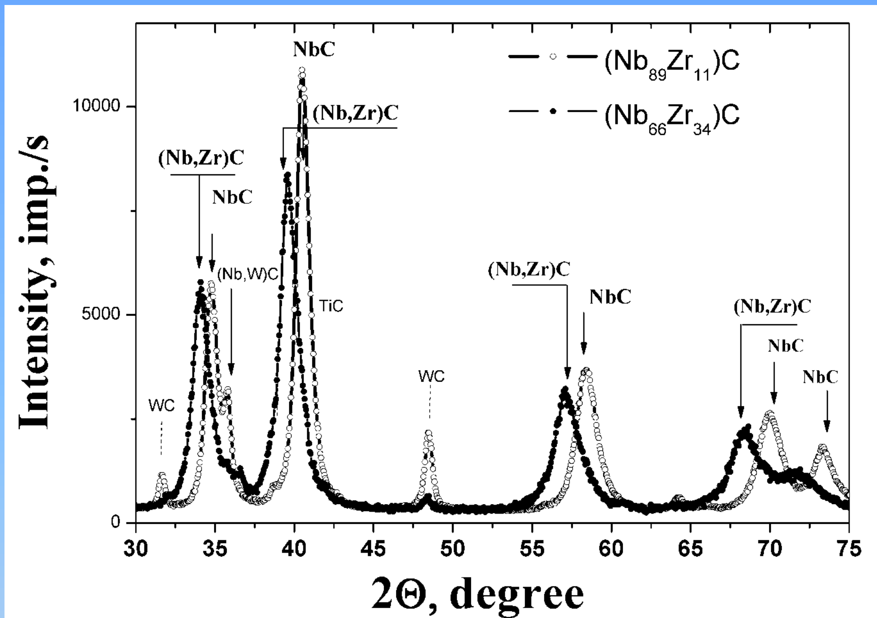
Why solid solution carbide coatings with NbC underlayers on hard alloy ?

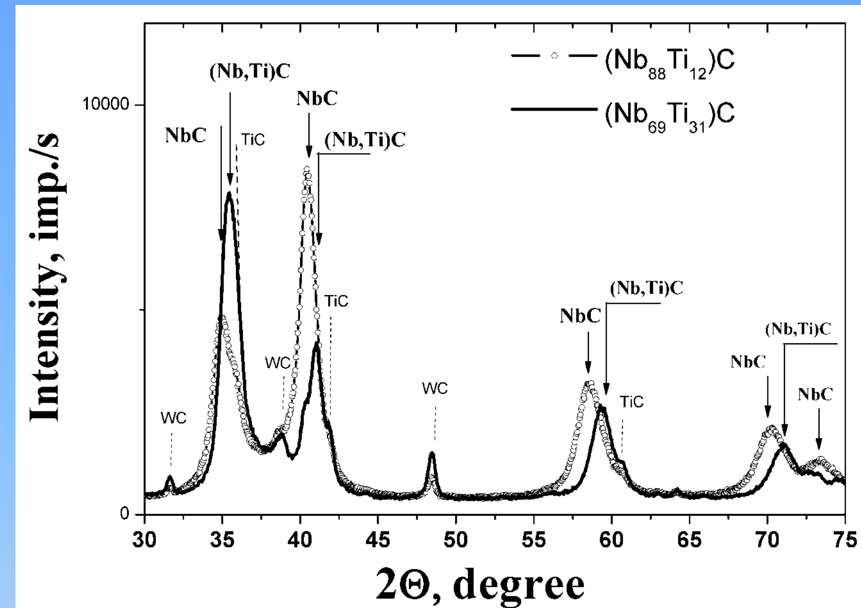
Promising coatings for increasing of carbide wood-cutting tool wear resistance could be high-hard multilayer thermostable carbide coatings formed in a single technological cycle of vacuum-arc ion bombardment and plasma deposition. Studies of the mechanical properties of niobium carbide coatings formed by the vacuum-arc method on a WC carbide tool showed the possibility of creating layered carbide coatings having a hardness of up to 50–60 GPa.

The preliminary action of an ion flux with an energy of 1 keV created by a vacuum-arc Nb source in the range of 1-2 minutes is of decisive importance. In this case, the surface temperature of the samples increases to 1300 °C. As a result of ion incorporation, heating, and diffusion, the layers of (Nb,W)C, carbides are formed in the hard alloy

***Aim* : study further possibilities for improving the mechanical properties of this type of refractory carbide layered coatings to increase the wear resistance of cutting carbide tools using the vacuum-arc method and use simultaneous plasma deposition from two metal cathodes Nb and Zr, Nb and Ti.**

XRD pattern of instrument samples with $Nb_{89}Zr_{11}C$, $Nb_{66}Zr_{34}C$; $Nb_{88}Ti_{12}C$, $Nb_{69}Ti_{31}C$ coatings created by ion exposure to niobium and plasma deposition using simultaneously two cathode sources Nb and Zr; Nb and Ti.



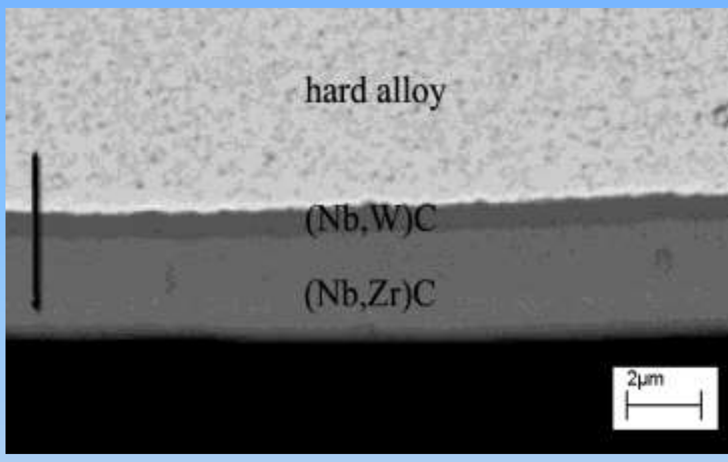


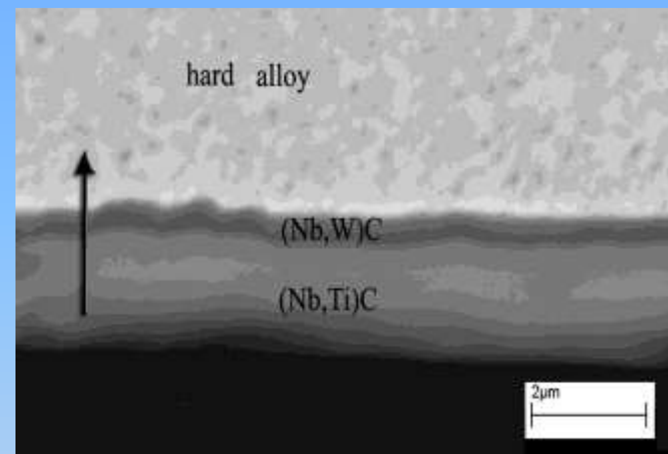
The metal content in the synthesized coatings on the hard alloy depending on the currents of the cathode arcs of metal sources.

Currents of cathode arcs of metal sources, A		The metal content in the coatings, %	
Nb	Zr	Nb	Zr
180	100	89	11
	120	66	34
	Ti		Ti
	100	88	12
	120	69	31

Cross-sectional scanning electron microscopy images of samples with coatings formed by Nb ion bombardment and plasma deposition by Nb and Zr (arc current 120 A) (a); Nb and Ti (arc current 100 A) (c) vacuum-arc sources and their corresponding intensity distribution of characteristic x-ray radiation of W, Co, C, Nb, Zr, Ti (b, d) along the arrows indicated in the figures (a, c).

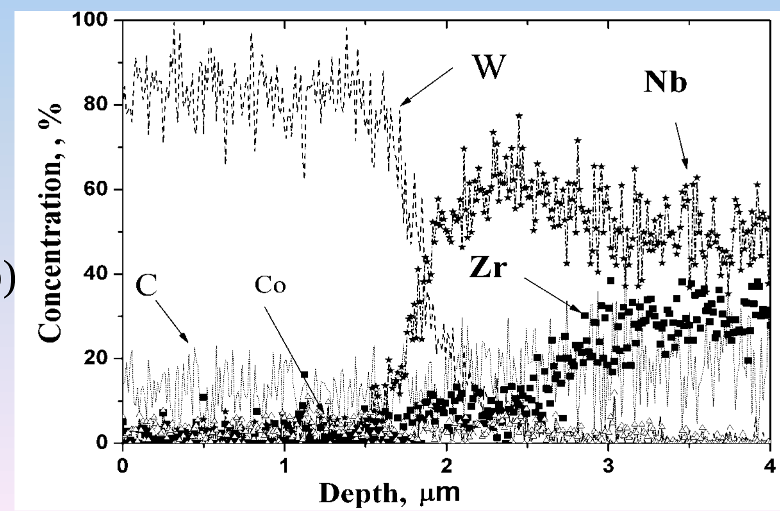
(a)

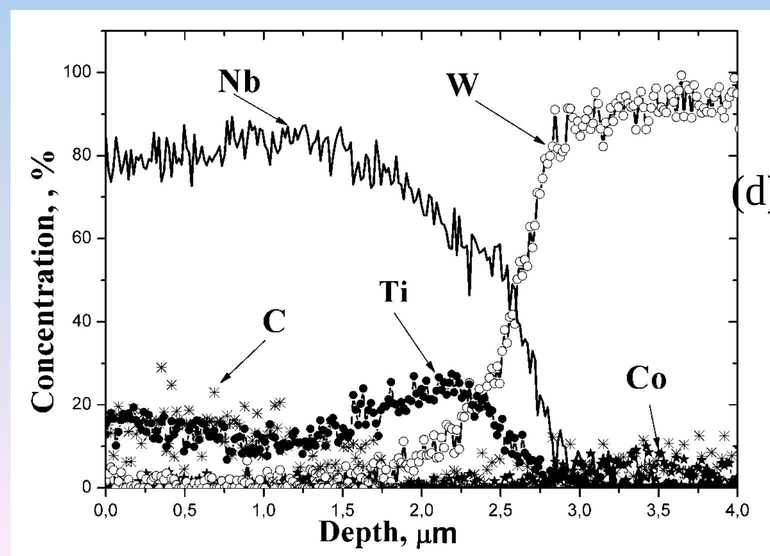




(c)

(b)





Mechanical properties and microstresses of layered carbide coatings on a hard alloy formed by Nb ion bombardment and vacuum arc deposition using one (Nb) and two metal cathodes Nb and Zr, Nb and Ti.

Sample	Load Hardness, GPa (error range: 2÷4 GPa) 1 N	Load Hardness, GPa (error range: 2÷4 GPa) 2 N	Flaking critical load, N (error : 20 N)	Wear, (10^{-16} m^3/N·m) (error range: (0,2÷0,3) 10^{-16} m^3/N·m)	Microstresses, GPa (error range: 0,3÷0,4 GPa)
Hard alloy	17	17	-	4,1	-
NbC/(Nb,W)C	66	61	110	1,0	1,0
$Nb_{89}Zr_{11}C$	62	60	140	0,4	1,4
$Nb_{66}Zr_{34}C$	65	62	140	0,5	2,3
$Nb_{88}Ti_{12}C$	61	42	120	0,8	2,1
$Nb_{69}Ti_{31}C$	58	39	110	0,9	2,8

Conclusions

Vacuum cathode-arc deposition with simultaneous combustion of two metal cathodes Nb and Zr, or Nb and Ti with preliminary intense ionic action of Nb forms layered coatings on the hard alloy from solid solutions (Nb,Zr)C, (Nb,Ti)C and a sublayer of (W,Nb)C. The uppermost layer a few microns thick is solid solutions of carbides (Nb,Zr)C or (Nb,Ti)C. Between it and the hard alloy there is a thinner layer (Nb,W)C with a thickness of up to 0.5 μm. The hardness, flaking critical load of these layered coatings from solid carbide solutions is very high (58-65 GPa), (110-140 N). The volumetric wear of the tool with these carbide coatings is 4-10 times less than the wear of the hard alloy without coating.